

[54] **INTEGRAL ECONOMIZER FOR U-TUBE GENERATOR**

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[51] Int. Cl. **F22b 1/16**

[58] Field of Search **122/32, 34; 165/114, 161**

[56] **References Cited**

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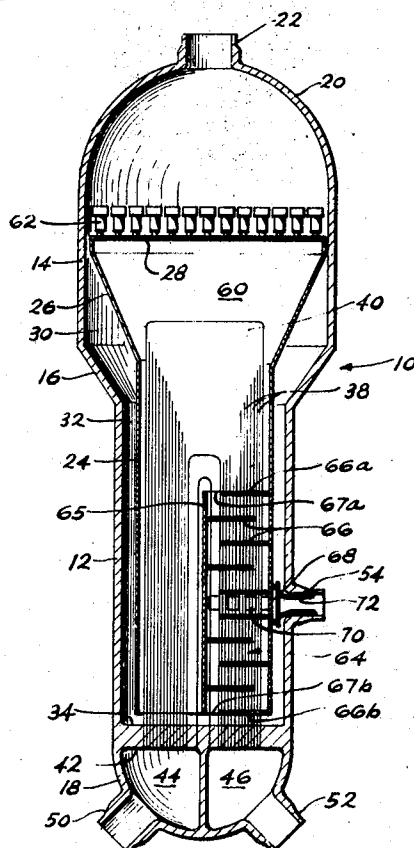
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Primary Examiner—Kenneth W. Sprague
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[57] **ABSTRACT**

An economizer compartment for a shell and tube vapor generator is disclosed in which the cold feed-water to be heated enters the compartment at an intermediate point along its length and is divided into two oppositely directed flow paths that exit the compartment at opposite ends. The compartment is disposed in spaced-apart relation from the adjacent interior surfaces of the vapor generator shell in order to protect the same against thermal shocking as a result of contact by unheated feedwater.

16 Claims, 2 Drawing Figures



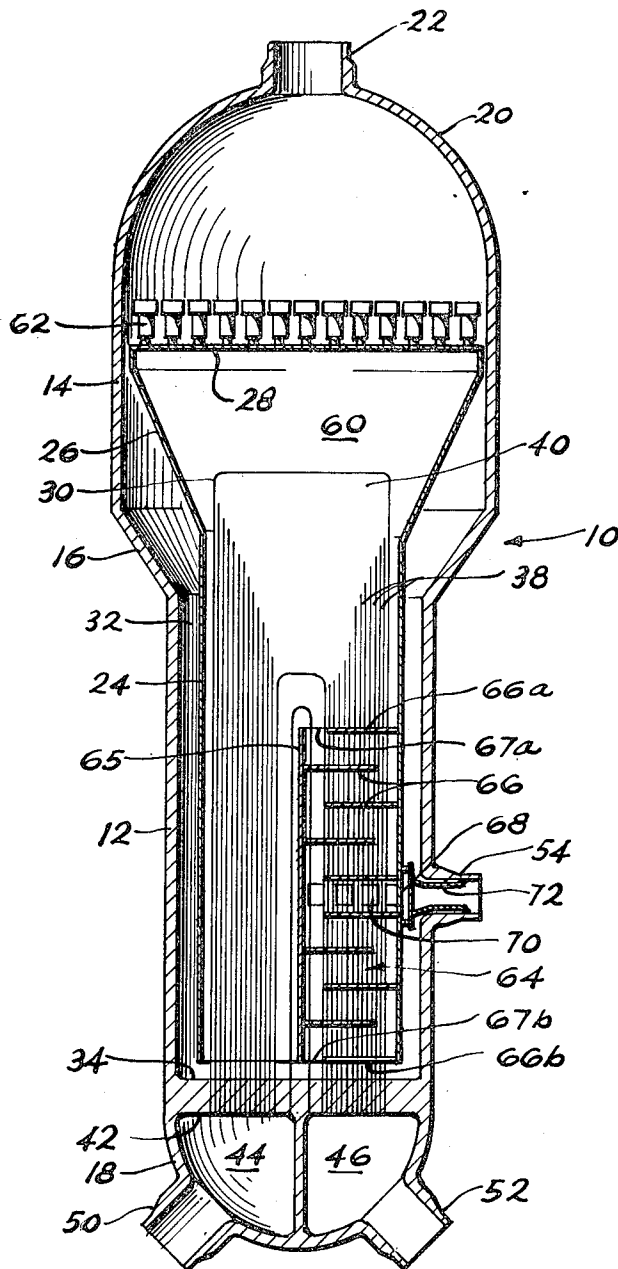
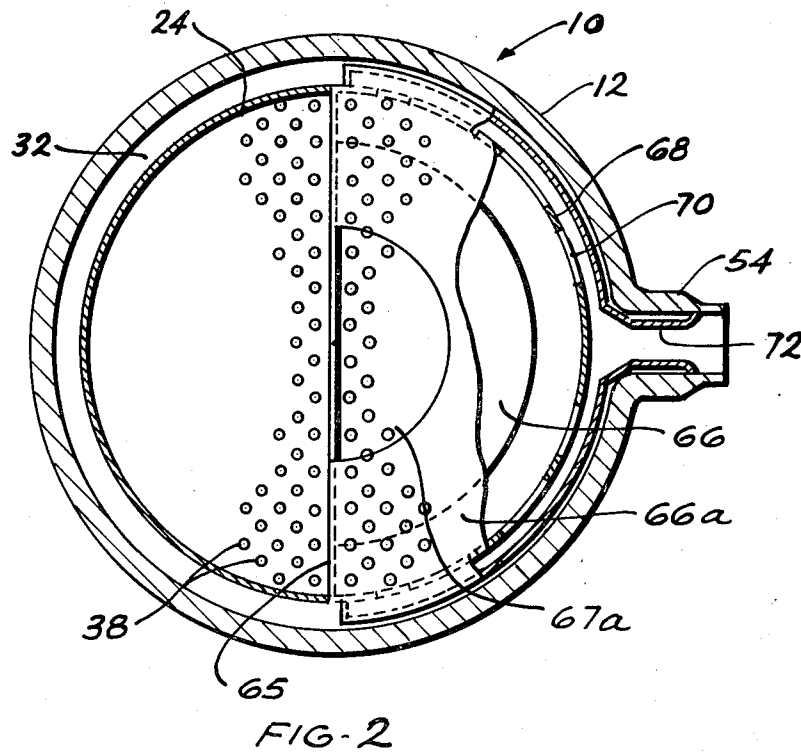


FIG-1

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INTEGRAL ECONOMIZER FOR U-TUBE GENERATOR

BACKGROUND OF THE INVENTION

The present invention relates in general to vapor generators of the shell and tube type wherein vaporizable liquid is transformed into vapor by passing it in heat exchange relation with a heating fluid that is conducted through the tubes. In vapor generators of this type, it is desirable to preheat feed liquid admitted to the unit to about saturation temperature prior to passing it to the evaporator section. This is done for two principal reasons. First, it reduces thermal gradients within certain of the component parts of the unit with which the feed liquid comes in contact in order to reduce the danger of overstressing these elements. And secondly, it causes boiling heat transfer to occur along substantially the full length of the heat exchange surface in the evaporator section thereby resulting in the unit's operating at greater thermal efficiency.

It is generally well known that the most effective manner of heating vaporizable liquids in such units is by the transfer of heat to the liquid from the heating fluid. This is due to the considerably greater temperature head existing between the hot and cold fluids that is made available. However, it is also well known that to preheat the feed liquid in this manner will expose some of the component parts of the unit to the inlet temperature of the incoming liquid. In order to overcome this problem, it has been proposed to provide shell and tube vapor generators with economizer chambers that are spaced from the adjacent surface of the shell and to circulate heated secondary liquid between the chamber and the shell so as not to thermally shock the shell material by contacting it directly with cold feedwater. Economizer chambers of the type referred to are exemplified in U.S. Pat. Nos. 3,356,135 to Sayre and 3,483,848 to Green.

In the utilization of such economizer chambers, however, certain other problems are manifest that reduce their desirability of use. A principal objection is the fact that, because cold feedwater contacts the lower end plate of the economizer compartment, differential thermal expansions occur between the plate and the adjacent region of the tube sheet. These differential thermal expansions create adverse bending stresses in the short tube lengths that extend between these members. This problem is aggravated by the fact that seals must ordinarily be provided between the tubes and the end plate in order to prevent leakage of unheated feedwater into contact with adjacent shell surfaces and to prevent the loss of thermal efficiency attendant with leakage bypass of the economizer. The fact that seals are present between the tubes and the compartment end plate, in addition to increasing the cost of constructing the unit, also creates the problem of having to accommodate the differential axial expansions between the tubes and the economizer compartment in a manner as to prevent overstressing the tubes in compression. The present invention, therefore, has as its principal object the design of an improved form of economizer compartment for a shell and tube generator which avoids the problems referred to.

SUMMARY OF THE INVENTION

According to the present invention an economizer compartment is provided which has liquid discharge openings at both ends. Within the compartment the incoming cold feedwater is caused to enter intermediate the ends whereupon the flow is divided and directed in opposite directions toward the discharge openings. The economizer chamber is dimensioned such that the liquid flowing along each flow path is heated to about saturation temperature prior to being discharged from the respective ends of the compartment to the communicating interior regions of the vapor generation chamber.

By reason of the invention, differential thermal expansions between the end plate of the economizer compartment and the tube sheet are reduced since the former is washed with higher temperature liquid as compared with comparable apparatus of the prior art. This, in turn, reduces the magnitude of the bending stresses imposed upon the tubes. Also, the need to seal present interface between the tubes and the openings in the end plate is eliminated because the liquid that leaks across the interface can be tolerated in view of the fact that it consists entirely of heated liquid in contradistinction to the leakage that would occur in comparable apparatus of the prior art.

For a better understanding of the invention, its operating advantages and the specific objectives obtained by its use, reference should be made to the accompanying drawings and description which relate to a preferred embodiment thereof.

DESCRIPTION OF THE DRAWING

FIG. 1 is an elevational view of a vapor generator employing an economizer chamber constructed according to the present invention; and

FIG. 2 is a cross-sectioned view taken along line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 of the drawings, there is shown a shell and tube-type vapor generator 10 incorporating the present invention. The vapor generator 10 comprises a vertically elongated pressure vessel defined by a lower cylindrical shell 12 and a larger diameter upper cylindrical shell 14 interconnected with the lower shell by means of a frustoconical transition member 16. The ends of the vessel are closed at the bottom by means of hemispherically formed closure head 18 and at the top of a domed-shaped cover 20 containing a vapor outlet nozzle 22. The interior of the pressure vessel contains baffle plate members 24, 26, and 28 that cooperate with the walls of the shells to form an interior vapor generation chamber 30 and an outer, annular downcomer passage 32. At the bottom end of the lower shell 12, and intermediate it and the closure head 18, is disposed a tube sheet 34 that extends transversely of the centerline of the vessel and connects with the wall of the shell. The tube sheet 34 contains a plurality of tube openings adapted to fixedly receive the ends of U-shaped heat exchange tubes 38 that form a longitudinally extending tube bundle 40 substantially filling the lower region of the vapor generation chamber 30.

The tube openings extend through the tube sheet 34 to place the ends of the tubes in fluid communication with a heating fluid chamber 42 which occupies that region of the vessel enclosed between the closure head and the tube sheet 34 and is divided into inlet and outlet portions, 44, 46 respectively, by means of a diametral plate 48. The tubes 38 of the tube bundle 40 are arranged such that the opposite ends communicate with one of the respective portions of the chamber 42 for the through-flow of heating fluid through the tubes. The chamber 42 is connected to a source of heating fluid (not shown) by means of inlet and outlet nozzles 50 and 52 that communicate with the respective chamber portions 44 and 46 thereby to effect circulation of heating fluid through the tubes.

Feedwater is supplied to the unit through an inlet nozzle 54 that penetrates lower shell 12. Within the vapor generator the feed-water is caused to flow in heat exchange relation with the tubes 38 where heat is extracted from the heating fluid circulated therethrough to first, effect preheating of the feedwater as hereinafter more fully described and secondly, to cause some of the heated feedwater to be transformed into vapor. The so-created vapor-liquid mixture flows to the upper region of the vapor generation chamber 30 which is formed as a mixture collection chamber 60 as defined by the cooperation between the baffle plates 26 and 28. From the mixture collection chamber 60 the flowing mixture is passed to vapor-liquid separator apparatus, a multiplicity of such separators, indicated as 62, being mounted on baffle plate 28 and connecting with the chamber 60 by means of openings provided in the plate. The separators 62 may be of any well-known construction and are arranged to discharge separated liquid downwardly onto the baffle plate 28 from whence it is returned to the downcomer passage 32 to be mixed with the preheated feedwater and recirculated through the unit. The separated vapor, on the other hand, is discharged upwardly from the separators and passed through vapor outlet nozzle 22 to a point of use.

The economizer compartment 64 is provided in the lower region of the interior of shell 12. Within it the entering feedwater, prior to being admitted to the vapor generation chamber 30, is heated to a predetermined temperature by heat transferred from the fluid flowing through that portion of tubes 38 that extend through the compartment. As shown, the compartment 64 comprises a vertically elongated chamber extending upwardly from a level slightly spaced above the tube sheet 34. It is constructed of a plurality of plate members preferably enclosing the lower temperature legs of the tubes 38 adjacent the discharge ends thereof. The compartment is bound about its radially outer periphery by the lower portion of the downcomer baffle 24. Its innermost side is defined by a vertical flat plate 65 that extends substantially diametrically through the tube bundle 40 and whose side edges are weldedly attached to the downcomer baffle 24. A number of vertically spaced transversely extending baffle plates 66 are disposed to conduct the feedwater through the compartment along a sinuous course to direct the flowing liquid in substantially crossflow relation to the tubes.

According to the invention the arrangement of the economizer compartment 64 is such that the feedwater

inlet nozzle 54 is caused to communicate with the interior of the compartment at a point intermediate its ends. Both the upper and lower ends, defined by transverse baffle plates, 66a and 66b respectively, are open, as indicated at 67a and 67b, to discharge heated liquid from the compartment to the vapor generation chamber 30. Feedwater admitted to the economizer compartment through the nozzle 54 first enters a distribution plenum 68 defined by plates extending from the outer surface of the lower portion of the downcomer baffle 24. Communication between the plenum 68 and the interior of the economizer compartment 64 is effected by a plurality of circumferentially spaced openings 70 in the baffle 24. An inlet pipe 72 concentrically spaced from the bore of nozzle 54 connects with the plenum and serves to conduct fresh feedwater 32 from an external source (not shown).

The operation of the vapor generator embodied in the present invention is as follows. Fresh feedwater enters the unit through the inlet nozzle 54 and concentric pipe 72 and is discharged into the plenum 68 from whence it passes through the circumferentially spaced openings 70 into the interior of the economizer compartment 64. Within the compartment 64 the flow of feed water is split with part being directed along an upward course sinusoidally along the path defined by the transverse baffles 66 in crossflow relation to the tubes 38. The other part of the feedwater flow is directed in similar fashion downwardly emerging from the bottom of the compartment in the space between the lower end plate 66b and the upper surface of the tube sheet 34. The liquid emerging from the compartment at both ends is preferably heated to about saturation temperature whereupon it enters the vapor generation chamber 30 to be passed in heat transfer relation to the heating surface presented by the tubes 38 in the tube bundle 40. In circulating through the vapor generation chamber 30 some of the liquid is transformed into vapor and the so-created vapor-liquid mixture rises to the upper region of the chamber 30 indicated as the mixture collection chamber 50 from whence it is passed through the separators 52. The liquid separated from the mixture within the separators is discharged into the downcomer passage 32 to be recirculated through the unit. The recirculated liquid enters the vapor generation chamber 30 at the lower end of the downcomer baffle 24 and is caused to be mixed with the preheated liquid that is discharged from the economizer compartment 64, the latter entering the chamber 30 at approximately the same temperature as the recirculated liquid. The separated vapor that emerges from the separators 52, on the other hand, is discharged from the vapor generator through the outlet nozzle 22 and is conducted to a point of use.

It will be observed that in disposing the economizer compartment 64 in spaced relation from the interior surface of the shell 12 and tube sheet 34, these latter members are protected against the imposition of undue thermal stresses that would otherwise occur were cold feedwater permitted to come in contact with them. By virtue of the fact that the feedwater flow within the economizer compartment is split and directed in two opposite directions several other attendant advantages also result. Firstly, the lower end plate of the compartment, indicated as 66b, is washed with liquid at about

saturation temperature thereby reducing the differential temperature that would otherwise exist between it and the tube sheet 34 were it to be contacted by unheated feedwater. The resultant bending stresses imposed upon the short tube lengths extending between the lower plate 66b and the tube sheet 34 are therefore concomitantly reduced. It will be further recognized that the feedwater leakage from the economizer compartment into the adjacent region of the vapor generator presents no serious problem because that feedwater which is leaked through the tube spaces provided in the lower end plate is heated to an elevated temperature and therefore the problem of shocking the adjacent, high temperature parts of the vapor generator is eliminated. Still further, since only heated feedwater is permitted to emerge from the lower end of the compartment as leakage, it is unnecessary to seal the holes in the end plate 66a through which the tubes pass. This, of course, results in significant savings in fabrication costs. It additionally avoids the problem of having to otherwise accommodate the longitudinal differential expansion occurring between the plate members of the economizer compartment 64 and the tubes 38 during operation of the vapor generator.

It will be understood that various changes in the details, materials, and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. In a shell-and-tube heat exchanger for the generation of vapor by the indirect transfer of heat from a heating fluid to a vaporizable liquid including a pressure vessel enclosing a bundle of heat exchange tubes and defining a vapor generating chamber, means for circulating heating fluid through said tubes and means for supplying vaporizable liquid to said vapor generating chamber, the improvement comprising:

- a. plate means defining an economizer compartment enclosing a portion of the heat transfer surface of said tubes and dividing said vapor generating chamber into a preheat section and an evaporator section;
- b. means defining openings at oppositely spaced ends of said compartment for discharging preheated liquid to said evaporator section;
- c. said means for supplying vaporizable liquid connecting with said compartment intermediate the ends thereof; and
- d. means within said compartment for conducting one part of said vaporizable liquid toward one of said discharge openings and the other part toward the other of said discharge openings.

2. The improvement as recited in claim 1 wherein said tubes are arranged to provide an amount of heat transfer surface within said economizer compartment to preheat each part of said vaporizable liquid to substantially the temperature of saturation thereof.

3. The improvement as recited in claim 1 wherein said parts of vaporizable liquid are substantially equal.

4. The improvement as recited in claim 1 wherein said compartment includes a plurality of baffle plate members for directing each part of said vaporizable

liquid in generally crossflow relation to the tubes extending through said compartment.

5. The improvement as recited in claim 1 wherein said tubes are disposed in generally parallel relation and conduct said heating fluid in similar directions through said compartment in substantial countercurrent relation to one of said parts of vaporizable liquid and substantial cocurrent relation to the other of said parts.

6. A shell-and-tube heat exchanger for the generation of vapor by the indirect transfer of heat from a heating fluid to a vaporizable liquid comprising:

- a. a generally vertically elongated cylindrical shell;
- b. transversely extending tube sheet means dividing the interior of said shell into a vapor generating chamber and heating fluid chamber means;
- c. a bundle of heat exchange tubes extending through said vapor generating chamber and having their ends attaching said tube sheet means in communication with said heating fluid chamber means for circulating heating fluid through said tubes;
- d. means for supplying vaporizable liquid to said vapor generating chamber;
- e. economizer means for preheating said vaporizable liquids including:
 - i. a plurality of plates defining a substantially axially elongated compartment in which heat is transferred to said vaporizable liquid disposed within said vapor generating chamber and dividing the same into an evaporator section and a preheat section,
 - ii. means defining openings adjacent the oppositely spaced ends of said compartment for discharging preheated liquid to said evaporator section,
 - iii. said vaporizable liquid supply means connecting with said compartment intermediate the ends thereof, and
 - iv. means within said compartment for conducting one part of said vaporizable liquid toward one of said discharge openings and the other part toward the other of said discharge openings.

7. A heat exchanger as recited in claim 6 wherein said compartment is defined by plate members enclosing a portion of said tube bundle.

8. A heat exchanger as recited in claim 7 wherein said compartment is disposed in spaced apart relation to the interior surface of said shell and tube sheet to define passage means for conducting heated liquid.

9. A heat exchanger as recited in claim 8 wherein said tube bundle comprises a plurality of vertically extending, generally U-shaped tubes and including a downcomer baffle surrounding said tubes in concentrically spaced relation to the internal surface of said shell to define an annular downcomer passage.

10. A heat exchanger as recited in claim 9 wherein said economizer compartment is defined about its outer periphery by a portion of the lower end of said downcomer baffle and about its inner periphery by a vertically extending planar plate whose end edges attach the inner surface of said downcomer baffle.

11. A heat exchanger as recited in claim 10 wherein said compartment includes a plurality of vertically spaced, transversely extending baffle plate members for directing each of the parts of the flow of vaporizable liquid in generally crossflow relation to the tubes extending through said compartment.

12. A heat exchanger as recited in claim 11 including transversely extending plates defining the upper and lower ends of said compartment, said plates containing means defining openings for establishing fluid communication between the interior of said compartment and the adjacent region of said evaporator section.

13. A heat exchanger as recited in claim 12 wherein the liquid discharged from said compartment to said evaporator section is at about saturation temperature.

14. A heat exchanger as recited in claim 12 wherein the lower end of said downcomer shroud is vertically spaced from the adjacent tube sheet and the lower end of said downcomer passage is in open fluid communication with said evaporator section adjacent the lower

end of said compartment.

15. A heat exchanger as recited in claim 10 including means forming a plenum disposed about at least a portion of said downcomer baffle, means connecting said vaporizable liquid supply means to said plenum, and means forming openings in said downcomer baffle for passing vaporizable liquid from said plenum to the interior of said compartment.

16. A heat exchanger as recited in claim 15 wherein said openings are circumferentially spaced about substantially the entire length of said downcomer baffle that is common with said plenum and said compartment.

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